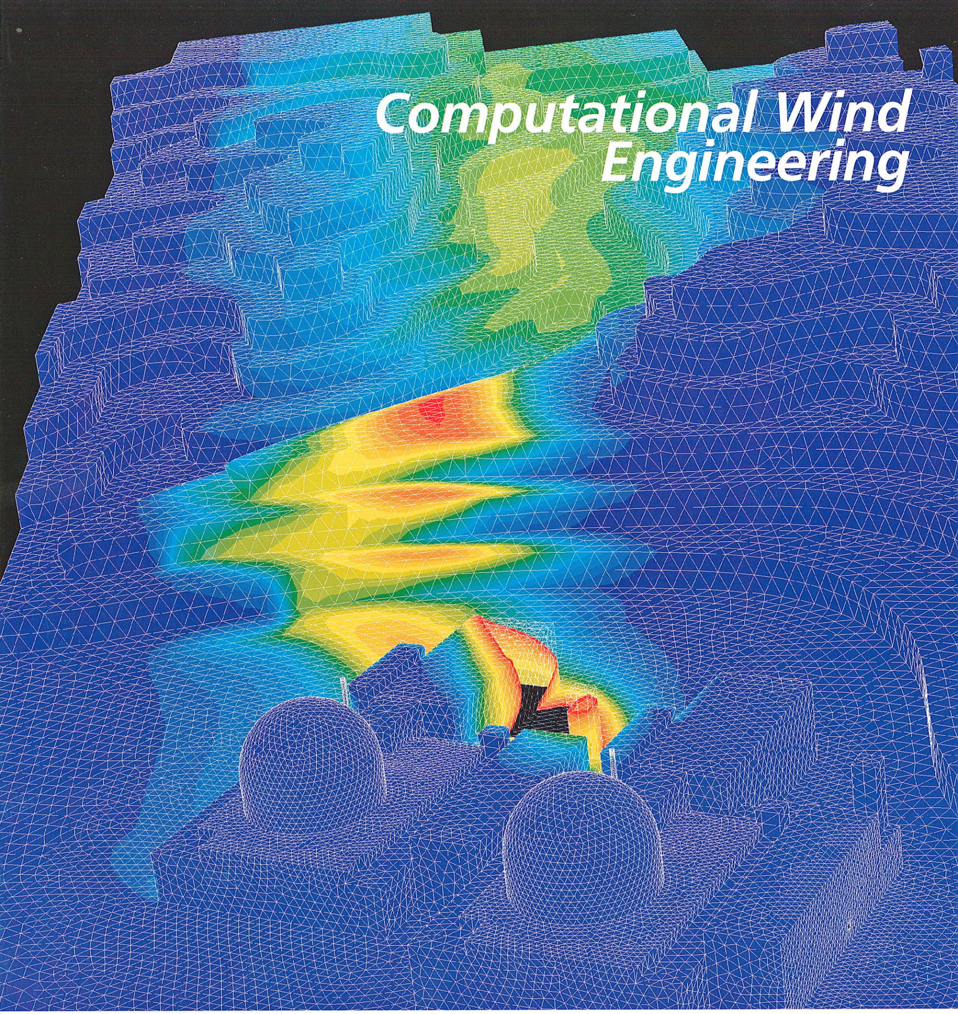
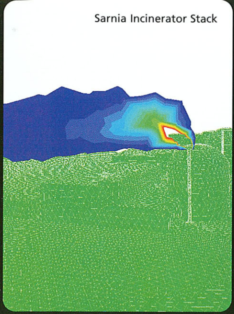
Computational Wind Engineering



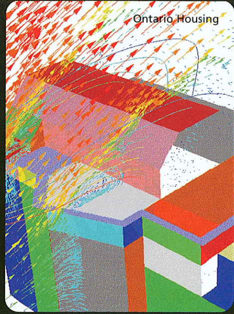
Alan G. Davenport
Wind Engineering Group

The Boundary Layer Wind Tunnel Laboratory

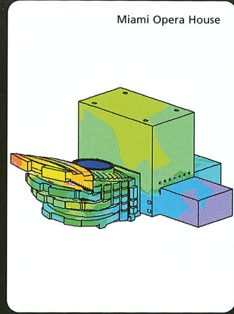
The reliability of any numerical simulation is measured by comparison with physical experiments. Wherever possible the Laboratory provides generic or case oriented benchmarking for its CWE simulations. The Boundary Layer Wind Tunnel is known for its accuracy and quality of work.



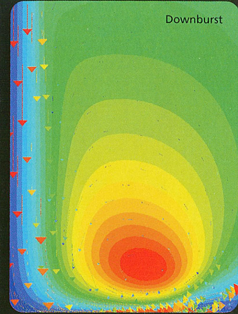
① Atmospheric Dispersion



② Wind-driven Rain



③ Internal Ventilation



④ High Intensity Winds

Computational Wind Engineering

In addition to and as a desirable extension of the wind tunnel experiments, the Boundary Layer Wind Tunnel Laboratory (BLWTL) has developed a Computational Wind Engineering (CWE) direction. Numerical experiments (simulations) are performed with state-of-the-art commercial codes such as FLUENT as well as through in-house developed, Large Eddy Simulation codes. The aim of the CWE direction at the BLWTL is to complement the well-established experimental capabilities of the Laboratory for studies such as Wind-driven rain impact on buildings, Atmospheric Dispersion of gaseous and particulate pollutants in complex terrain under thermal stratification conditions, Internal Ventilation and Air Quality for complex atriums, Bluff Body Aerodynamics and Fluid-structure interaction problems.

QUALITY WORK

The BLWTL is known for its accuracy and quality of work. All the CWE studies have been developed and calibrated versus wind tunnel experiments for generic situations. The results of these calibrations have been documented through international journal and conference publications and are made available to our clients.

EXPERIENCED STAFF

The CWE direction at the BLWTL retains experienced high-tech professionals. Since its inception in 1996 the CWE group has played a leading role in Computational Wind Engineering. We have assisted designers and clients of international renown by evaluating flow and pollutant fields in most complex terrains, validating HVAC systems in the world's largest amphitheatres or investigating the detailed effects of wind-driven rain on buildings.

VALUABLE EXPERTISE

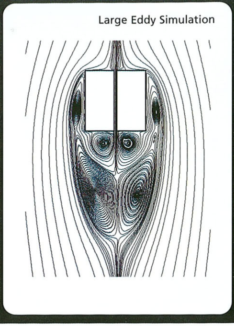
The CWE group at the BLWTL capably simulates gaseous or particulate concentrations or depositions in complex geometries and under non-uniform flow or temperature field conditions. We investigate the flow, temperature and any passive scalar transport associated with both architectural and industrial internal domains from atriums to industrial incinerator units. The CWE numerical studies frequently lead to cost savings or design improvements.

TIMELY COMMUNICATIONS

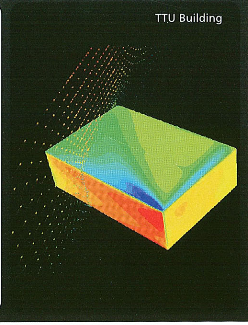
An early involvement of the CWE group at the BLWTL results in greatest benefits. Numerical simulations are valuable preliminary design tools fit to provide essential parametric studies for the final design. By working closely with our clients on an ongoing basis, we assist in identifying needs in order to provide timely and accurate design information at a reasonable cost.

BLWTL Computational Wind Engineering studies are important to:

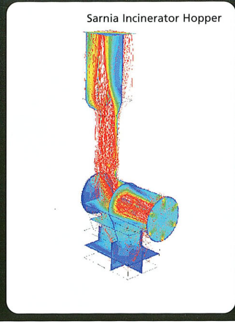
- provide a complete description of flow and concentration fields in complex topographic terrains
- study the effect of thermal stratifications on flow and concentration fields
- test and/or improve the HVAC design for geometrically complex halls, atriums or terminals
- enhance air quality and ensure human safety and comfort criteria inside buildings through tracking of passive scalar (gaseous and particulate pollutant, smoke) transport across the envelope
- determine the wind-driven rain impact on buildings and assist in the design of rain protection and drainage systems
- assist in the assessment of catastrophic impacts on buildings and structures due to high intensity winds (downbursts and tornadoes), fire and water propagation, missile type impacts



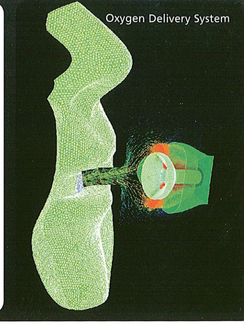
⑤ Bluff Body Aerodynamics



⑥ Wind Effects on Buildings



⑦ Internal Flows



⑧ Biomedical Flows

ATMOSPHERIC DISPERSION

Numerical simulations of atmospheric dispersion of pollutants expand the wind tunnel capabilities by providing the entire pollutant concentration envelope (as opposed to a couple of grid points). It also allows for the simulation of thermal stratifications in the atmospheric boundary layer and in the immediate vicinity of buildings to:

- determine ground level as well as multilevel horizontal and vertical concentration planes in the domain
- simulate in detail buildings and topography
- provide comparisons with generic wind tunnel and analytical models

INTERNAL VENTILATION AND AIR QUALITY

Numerical simulations of internal flow dynamics expands the external aerodynamics wind tunnel studies to the internal building envelope in order to:

- determine the velocity and temperature fields produced by an internal ventilation (HVAC) system
- determine the mixture fraction between freshly supplied air and old air in the domain as well as the time for a complete air exchange
- visualize the air movements in the domain by particle injections
- simulate the smoke or pollutant propagation inside the building
- help optimizing the HVAC system by changing the geometry, the flow parameters and/or the location of air supplies and air returns

WIND-DRIVEN RAIN IMPACT ON BUILDINGS

Numerical simulation of raindrop trajectories and wetting of buildings allows us to:

- determine the wetting patterns on building envelopes to determine staining of cladding
- determine the amount of water accumulating on buildings to help in designing the drainage systems
- determine the effectiveness of rain-protection systems such as barriers, parapets or cornices

HIGH INTENSITY WIND IMPACT ON STRUCTURES

High Intensity Winds (HIW) are short duration and high intensity thunderstorm related wind events that impact structures differently from the wind tunnel simulated boundary layer (synoptic) winds. Numerical simulations can:

- provide the velocity and pressure fields associated with these HIW events
- provide an input for structural loading
- interface with mesoscale meteorological models to enhance predictions
- provide a tool for the design of new wind laboratory facilities such as downburst simulators or tornadic chambers

ADDITIONAL SERVICES

Any study related to flow dynamics could be numerically modeled. While the CWE group at the BLWTL has developed expertise focusing on Wind Engineering related problems studies of other nature have been performed as well:

- improvement of ash particle deposition in incinerator systems
- design validation and optimization for oxygen delivery systems
- various flow control problems

Environmental Problems

- Winds in city streets and other public areas
- Dispersion of gaseous and particulate pollutants
- Rain penetration
- Influence of wind on HVAC
- Information provided to assist with curtain wall testing

Full-scale Monitoring

- Monitoring of wind response of full-scale structures

Wind Climate Studies

- Hurricane and severe storm effects
- Influence of large-scale topography on wind patterns
- Monte Carlo simulation of hurricane winds

Damping of Structures

- Estimation of inherent damping of buildings and structures
- Visco-elastic, tuned mass and tuned liquid dampers, and other damping systems

Other Design Challenges

- Aerodynamic efficiency of shapes and profiles
- Dynamics of foundations and structures
- Wind hazard assessment
- Fatigue and load cycle evaluation
- Snow drifting and accumulations on roofs and at ground level

Alan G. Davenport Wind Engineering Group

The University of Western Ontario, Faculty of Engineering, London, Ontario
Canada N6A 5B9 **Tel: (519) 661-3338** Fax: (519) 661-3339
Internet: www.blwtl.uwo.ca E-mail: info@blwtl.uwo.ca

CREDITS

Cover: AECL, Canada ① Safety-Kleen, Sarnia, Canada ② CMHC, McCallum Sather Architects, Enemodal Eng., Canada ③ Cesar Pelli & Associates, USA ④ Manitoba Hydro, Manitoba, Canada/Institute for Catastrophic Loss Reduction, UWO, London, Canada ⑤ NSERC, Canada ⑥ Alan G. Davenport Wind Engineering Group, BLWT Laboratory, UWO, London, Canada ⑦ Safety-Kleen, Sarnia, Canada ⑧ Southmed Inc., Barrie, Canada